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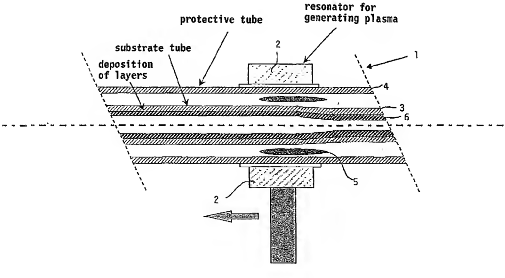
(54) Title: METHOD AND DEVICE FOR MANUFACTURING OPTICAL PREFORMS, AS WELL AS THE OPTICAL FIBRES OBTAINED THEREWITH



(57) Abstract: The present invention relates to a method and a device for manufacturing optical preforms, in which one or more layers of glass, doped or undoped, are deposited onto the internal surface of a hollow substrate tube, which deposition is effected by supplying one or more reactive gas mixtures of glass-forming compounds tot the interior of the hollow substrate tube and subsequently generating a non-isothermal plasma in the hollow substrate tube, after which the preform is subjected to a contraction process for the purpose of forming a massive rod, from which optical fibres are drawn.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Method and device for manufacturing optical preforms, as well as the optical fibres obtained therewith

The present invention relates to a method and a device for manufacturing optical preforms, in which one or more layers of glass, doped or undoped, are deposited onto the internal surface of a hollow substrate tube, which deposition is effected by supplying one or more reactive gas mixtures of glass-forming compounds to the interior of the hollow substrate tube and subsequently generating a non-isothermal plasma in the hollow substrate tube, after which the hollow substrate tube or preform, on the internal surface of which a plurality of layers of glass obtained by means of a deposition process are present, is subjected to a contraction process for the purpose of forming a massive rod, from which optical fibres are drawn. The present invention furthermore relates to optical fibres that are obtained by using such a method and device.

From US Pat. No. 4,746,345 there is known a method of manufacturing solid quartz glass preforms from hollow substrate tubes, in which a plasma burner consisting of two quartz tubes and a coil is reciprocated along the length of a hollow substrate tube. The plasma is ignited and maintained in the gaseous atmosphere that envelopes the substrate tube to be contracted, in which the dimension of the plasma burner is significantly smaller than the length of a substrate tube.

From US Pat. No. 5,203,691 there is known a burner which is used for contracting hollow substrate tubes into solid massive preforms, which process does not employ plasma, however.

A method of manufacturing optical fibres is known per se from US Pat. Nos. 4,314,833; 4,844,007 and Re. 30.635. The optical fibres produced by such a method may consist of a core of doped silica glass and a cladding of undoped silica glass. Alternatively, the fibre may consist of a core of either undoped or doped silica glass, a first cladding layer of doped silica glass, and an outer cladding of undoped silica glass. The

dopant, depending on its type, may increase or decrease the refractive index of silica. Dopants such as GeO_2, Al_2O_3, and TiO_2 will increase the refractive index, while dopants such as B_2O_3, or F will decrease the refractive index. In an optical fibre, the refractive index of the core layer material is higher than the layer of glass surrounding the core. There may be a stepped increase or a parabolic increase of the core refractive index.

In the aforesaid two US patents, the preform from which the optical fibre is drawn in a draw tower is produced in two separate steps, viz. a) the deposition of a number of thin, doped or undoped layers of quartz on the internal surface of the hollow preform or substrate tube, followed by b) the contracting or collapsing process, in which the previously obtained hollow substrate tube, which is internally coated with layers of quartz, is formed into the final massive preform by moving high-temperature heating means along the tube. According to this known PCVD-process, the deposition of the doped or undoped layers of quartz on the interior of the hollow substrate tube is effected by generating a plasma in a reactive gas mixture that is present within the substrate tube. Said reactive gas mixture is maintained at the desired chemical composition and the desired low pressure by means of a control system, and the plasma is generated by microwave rays whose energy is coupled into the ionised reactive gas mixture in a substrate tube from a resonator which is disposed outside the substrate tube. A so-called circular symmetrical deposition of layers of glass, which is substantially uniform in the longitudinal direction of the hollow substrate tube, is obtained by moving the resonator in the longitudinal direction with respect to the hollow substrate tube. In order to achieve an optimum deposition process, the hollow substrate tube is maintained at a temperature of about 1200 °C by placing the whole of substrate tube and moving resonator in a movable furnace, in which the resonator is provided with an insulating envelope so as to ensure the proper functioning

thereof, and in which furthermore cooling of the resonator takes place. After completion of the deposition process as described above, the substrate tube comprising the layers of glass internally deposited thereon is manually removed from the PCVD apparatus and subsequently set up in a contraction apparatus. Usually, a hydrogen-oxygen burner or an electrical furnace is used for the contraction process, in which case the hollow substrate tube is formed into the desired massive preform in a number of passes. A massive rod thus obtained, also called preform, possibly being externally coated with additional glass, is set up in a draw tower and an optical fibre is drawn therefrom.

The process of preform manufacture as described above can thus be considered to be a method in which two separate process steps can be distinguished, each step to be carried out in a separate apparatus. An important drawback is the fact that, owing to the cooling of the substrate tube that takes place upon transfer of the tube, the internal stress in the layers deposited on the interior of the substrate tube will increase to such an extent that a so-called "layer breakage" will occur, which renders the substrate tube unsuitable for further processing in the draw tower. Such a "layer breakage" results in preform losses, which phenomenon occurs in particular when manufacturing preforms exhibiting a high refractive index contrast or large differences between the coefficients of thermal expansion of the deposited layers resulting from the use of one or more types of dopants. Such a phenomenon occurs in particular when producing specific types of multimode fibres, fibres for sensor applications, photosensitive fibres, fibres for dispersion compensating modules, fibres containing special reinforcing dopants for amplification properties and the like. It is desirable to use higher refractive index contrasts, higher amounts of dopants and/or different types of dopants when designing such fibres. The production techniques that are commercially available at present only allow the production of fibres having a maximum refractive index contrast of about 2%, however,

and the fibres are usually so-called graded index fibres. It is desirable, therefore, that optical fibres be produced in which specific layers exhibit a refractive index contrast higher than the that which is known according to the prior art, in particular a value higher than 2.5%.

If it is decided to use dopants in a specific layer of an optical fibre whose structure strongly differs from the undoped quartz structure, this will lead to major differences between the coefficients of thermal expansion. In the prior art, a maximum difference of 3.2×10^{-6} K^{-1} in the coefficients of thermal expansion of the various layers arranged adjacently to each other was considered to be attainable when manufacturing optical fibres. If, on the other hand, it should be decided to use special dopants, it is desirable that optical fibres be produced in which the differences between the coefficients of thermal expansion of the layers arranged adjacently to each other may be larger than the aforesaid value, in particular larger than 3.4×10^{-6} K^{-1}.

It should be understood that if layers exhibiting large differences in the coefficients of thermal expansion are present in the substrate tube, stress differences between the layers may occur upon cooling down, which may lead to the development of lines of fracture in the various layers, and, in the worst case, to fracture of the entire preform. In practice it has moreover become apparent that the aforesaid separate process steps may lead to drawbacks, in particular upon removal of the substrate tube from the PCVD apparatus and the subsequent setting-up of the substrate tube in the contraction apparatus, which operations may lead to fouling of the internal surface of the substrate tube.

One aspect of the present invention is thus to provide a method and a device for manufacturing optical preforms which do not exhibit the problems of the prior art as referred to above.

Another aspect of the present invention is to provide a method and a device for manufacturing optical preforms, which optical preforms are composed so that optical fibres exhibiting a high refractive

index contrast can be drawn therefrom.

Another aspect of the present invention is to provide a method and a device for manufacturing optical preforms, according to which optical fibres can be drawn from said optical preforms, which optical fibres are composed of one or more layers whose coefficients of thermal expansion differ strongly from each other.

Yet another aspect of the present invention is to provide a method and a device for manufacturing optical preforms, according to which a non-isothermal plasma is used both in the contraction process and in the deposition process.

An additional object of the present invention is to provide a method and a device for manufacturing optical preforms, according to which the deposition process and the contraction process are carried out in one and the same device, viz. an integrated PCVD/collapsing machine.

The invention as referred to in the introduction is characterized in that the contraction process comprises the steps of:

i) providing a hollow substrate tube enveloped by a protective tube, which protective tube is stationary with respect to the hollow substrate tube, with the hollow substrate tube being enveloped by the protective tube along substantially the entire length thereof,

ii) providing a resonator which surrounds the protective tube,

iii) supplying a plasma-forming gas to the annular space present between the outer circumference of the hollow substrate tube and the inner circumference of the protective tube,

iv) generating a non-isothermal plasma in said annular space,

v) reciprocating the resonator in longitudinal direction with respect to the protective tube for the purpose of contracting the hollow preform into a massive rod, followed by controlled cooling thereof.

The use of a protective tube as described in step i) makes it possible to use the same microwave energy source that is used for the deposition process and for the contraction process as well. Thus, a plasma to be used in the contraction process is generated in the annular space present between the outer circumference of the hollow substrate tube and the inner circumference of the protective tube, which plasma generation takes place in such a manner that the microwave energy being used is relatively high whilst the resonator speed is low. In addition, the special construction of the protective tube and the substrate tube, according to which in particular the substrate tube is enveloped by the protective tube along substantially the entire length thereof, enables a reproducible and controllable contraction of the substrate tube. In the present description the term hollow substrate tube or preform is consistently used. These two terms are in fact considered to be synonyms by those skilled in the art, and it will become apparent from the context whether or not layers are already internally deposited thereon.

In a special embodiment it is desirable to introduce a gas having a high temperature into the annular space present between the outer circumference of the hollow substrate tube and the inner circumference of the protective tube during the deposition process. This makes it possible for the outer wall of the substrate tube to reach the same temperature as in the situation in which an external furnace is used.

In a special embodiment, on the other hand, it is possible to carry out the present contraction process in such a manner that the same plasma that was used for the deposition process is also used in carrying out the first contraction step. Such an embodiment enables much smaller differences to be chosen between the diameter of the outer circumference of the substrate tube and that of the outer circumference of the protective tube than originally. In addition to that, the conditions in which the circular plasma is to be generated in the annular

space in such an embodiment are significantly more favourable than in the situation in which a large difference between the respective diameters is employed.

It is in particular preferable to keep the hollow substrate tube and the protective tube in a horizontal position while carrying out the steps i)-iv), with the hollow substrate tube being rotated in particular during step v).

In order to obtain a uniform contraction of the substrate tube, the plasma is preferably adapted to the increased volume of the annular space during step v).

Preferably, a mixture of argon and oxygen is used as a suitable plasma-forming gas to be used in step iii), in which the pressure during the contraction process is preferably < 50 mbar, in particular 10-25 mbar.

It should be understood that the contraction into a fully massive rod can be terminated prematurely in step v), for which contraction, as described at some length in the foregoing, the same plasma as used in the deposition process and/or the plasma generated in the annular space may be used. Such premature termination may be desirable for special products or in order to have the closing of the preform take place in the melting zone of the draw tower.

Preferably, the protective tube is made of a ceramic material having a higher plasticizing temperature than the material of the hollow substrate tube to be contracted, in order to prevent the protective tube that envelopes the hollow substrate tube from plasticizing during step v) already.

In a special embodiment, in which repeated use of the protective tube for carrying out the steps i)-v) must be possible, the protective tube is preferably provided with cooling means, for example by forming hollow channels in the outer wall of the protective tube, in order to prevent premature contraction of the protective tube.

In a special embodiment, the protective tube used in step i) preferably functions as a jacket tube for the massive preform as well, which means that the contraction process comprises an additional step vi), which step vi) comprises the reciprocating of the resonator in longitudinal direction with respect to the protective tube for the purpose of contracting the protective tube, and the subsequent controlled cooling thereof. In such an embodiment the protective tube can be considered to be a jacket tube for the massive preform, after which the whole is set up in the draw tower as a complete preform for producing optical fibres.

In particular, the deposition process and the contraction process are carried out in one and the same device, in which the construction for effecting the rotating passage is designed such that the removal of the eventually obtained massive preform and the protective tube can take place in a simple manner. In order to obtain such a construction, clamps supporting the protective tube and the end of the substrate tube have an open construction.

It should be understood that the gas being used in step iii) may comprise one or more glass-forming compounds, so that an additional deposition takes place on the inner circumference and/or the outer circumference of the hollow protective tube.

Using the present invention, it is thus possible to manufacture optical preforms which exhibit a high refractive index contrast or large differences between the coefficients of thermal expansion of the various layers deposited on the interior of the hollow substrate tube.

The present invention thus furthermore relates to an optical fibre characterized in that the refractive index contrast

$$\Delta_i = \frac{n_i^2 - n_{cl}^2}{2 \cdot n_i^2} \cdot 100\%$$

wherein:

Δ_1 = refractive index contrast of specific layer i,

ni = refractive index of layer i,

n_{cl} = refractive index of the cladding, i.e. the outer layer of the fibre

has a value wherein $\Delta_1 > 2{,}5\%$, in particular $\Delta_i > 3\%$.

The present invention furthermore relates to an optical fibre characterized in that in that the thermal coefficient of expansion

$$\alpha = \frac{1}{l_0} \cdot \frac{\Delta l}{\Delta T} \ [\mathrm{K}^{-1}]$$

measured at a temperature of 25-300 °C, wherein:

l = length at T_1

l_0 = length at T_0

ΔT = $(T_1 - T_0)$

Δl = $(l - l_0)$

has a value according to which $\alpha > 3{,}4.10^{-6}$ K^{-1}, in particular $\alpha > 4{,}0.10^{-6}$ K^{-1}.

The present invention furthermore relates to a device for carrying out the method as described above and defined in the independent apparatus claim.

The present invention will be explained in more detail hereinafter by means of an example and with reference to a Figure; it should be noted, however, that the present invention is by no means

limited to such a special example and such a Figure.

The appended Figure schematically shows the position of the protective tube and the substrate tube according to the present invention.

Example.

The construction 1 that is shown in the Figure comprises the situation in which deposition of layers of glass (indicated at 6) on the internal surface of the substrate tube 3 has already taken place. The substrate tube 3 or preform 3 is enveloped by a protective tube 4, which protective tube 4 is surrounded by a device 2 for generating plasma, in particular a resonator which can be moved along the length of the protective tube 4. The generation of the plasma in the annular space (indicated at 5) present between the outer circumference of the preform 3 and the inner circumference of the protective tube 4 results in contraction of the preform 3 for the purpose of obtaining a massive or non-massive rod.

The present invention has been implemented in the design of a preform doped with dopant A (GeO_2). The resulting maximum index contrast thereof is more than 2.5% and the difference between the coefficient of thermal expansion of this layer and that of the cladding is greater than $3.4.10^{-6}$ K^{-1}. The present invention has also been implemented in the design of a preform doped with dopant A as described above, and with substance B as a co-dopant. The difference between the coefficient of thermal expansion of this layer and that of the cladding is greater than 4.10^{-6} K^{-1} in this case.

The protective tube being used is a tube having an external diameter of 34 mm and a wall thickness of 4 mm. The substrate tube being used has an external diameter of 22 mm and a wall thickness of 2 mm. Given a thickness of the deposited material of 1 mm in total, a massive rod of 14.6 mm is obtained after contraction in the case of a substrate tube firing loss during contraction of about 10%. After fitting of a

separate jacket tube having a cross-sectional area of 300 mm^2, the preform from which the desired optical fibre can be drawn is obtained. In the case of a diameter of 125 µm, the desired core diameter of 7 µm results if 0.029 mm of the final deposited layers has been deposited as the core material during the PCVD-process. The diameter of the total deposited layers in the fibre is 48.5 µm. Given a useful preform length of 40 cm, a length of fibre of 15 km can be produced from said preform.

CLAIMS

1. A method for manufacturing optical preforms, in which one or more layers of glass, doped or undoped, are deposited onto the internal surface of a hollow substrate tube, which deposition is effected by supplying one or more reactive gas mixtures of glass-forming compounds to the interior of the hollow substrate tube and subsequently generating a non-isothermal plasma in the hollow substrate tube, after which the substrate tube provided with layers of glass by means of a deposition process is subjected to a contraction process for the purpose of forming a massive rod, from which optical fibres are drawn, characterized in that the contraction process comprises the steps of:

i) providing a hollow substrate tube enveloped by a protective tube, which protective tube is stationary with respect to the hollow substrate tube, with the hollow substrate tube being enveloped by the protective tube along substantially the entire length thereof,

ii) providing a resonator which surrounds the protective tube,

iii) supplying a plasma-forming gas to the annular space present between the outer circumference of the hollow substrate tube and the inner circumference of the protective tube,

iv) generating a non-isothermal plasma in said annular space,

v) reciprocating the resonator in longitudinal direction with respect to the protective tube for the purpose of contracting the hollow preform into a massive rod.

2. A method according to claim 1, characterized in that the hollow substrate tube and the protective tube are kept in a horizontal position while steps i)-iv) are being carried out.

3. A method according to any one or more of the preceding claims, characterized in that the hollow substrate tube is rotated during

step v), followed by controlled cooling thereof.

4. A method according to any one or more of the preceding claims, characterized in that the plasma is adapted to the increased volume of the annular space during step v).

5. A method according to any one or more of the preceding claims, characterized in that a mixture of argon and oxygen is used as a plasma-forming gas.

6. A method according to any one or more of the preceding claims, characterized in that the pressure during the contraction process is < 50 mbar, in particular 10-25 mbar.

7. A method according to any one or more of the preceding claims, characterized in that a gas having a high temperature during the deposition process is introduced into said annular space.

8. A method according to any one or more of the preceding claims, characterized in that the protective tube is made of a ceramic material having a higher plasticizing temperature than the material of the hollow substrate tube to be contracted.

9. A method according to any one or more of the preceding claims, characterized in that the contraction process comprises an additional step vi), which step vi) comprises the reciprocating of the resonator in longitudinal direction with respect to the protective tube for the purpose of contracting the protective tube.

10. A method according to any one or more of the preceding claims, characterized in that the protective tube is provided with cooling means.

11. A method according to any one or more of the preceding claims, characterized in that the deposition process and the contraction process are carried out in one and the same device.

12. A method according to any one or more of the preceding claims, characterized in that the contraction process is carried out following on the deposition process.

13. A method according to any one or more of the preceding claims, characterized in that one or more glass-forming compounds is (are) added to the gas used in step iii).

14. A method according to any one or more of the preceding claims, characterized in that the contraction into a fully massive rod is terminated prematurely in step v), for which contraction the same plasma as used in the deposition process and/or the plasma generated in the annular space may be used.

15. An optical fibre, characterized in that the refractive index contrast

$$\Delta_i = \frac{n_i^2 - n_{cl}^2}{2 \cdot n_i^2} \cdot 100\%$$

wherein:

Δ_1 = refractive index contrast of specific layer i,

ni = refractive index of layer i,

n_{cl} = refractive index of the cladding, i.e. the outer layer of the fibre

has a value according to which Δ_1 > 2,5%.

16. An optical fibre according to claim 15, characterized in that Δ_i > 3%.

17. An optical fibre, characterized in that in that the thermal coefficient of expansion

$$\alpha = \frac{1}{l_0} \cdot \frac{\Delta l}{\Delta T} \ [K^{-1}]$$

measured at a temperature of 25-300 °C, wherein:

l = length at T_1

l_0 = length at T_0

ΔT = (T_1-T_0)

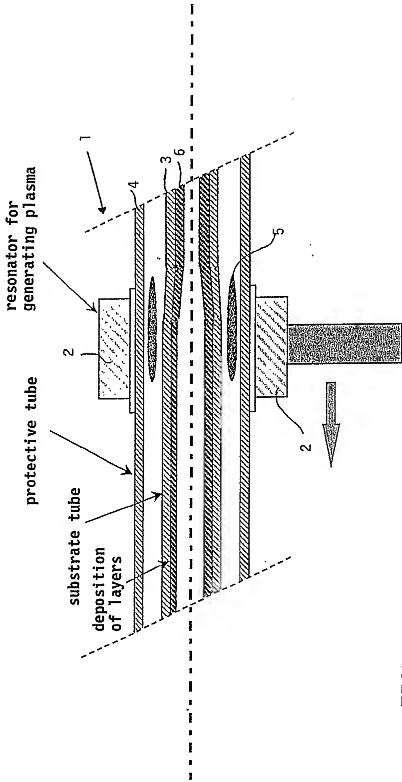
Δl = $(l-l_0)$

has a value according to which $\alpha > 3{,}4.10^{-6}$ K^{-1}.

18. An optical fibre according to claim 17, characterized in that $\alpha > 4{,}0.10^{-6}$ K^{-1}.

19. A device for contracting a substrate tube into a massive or non-massive preform, comprising means for rotating the substrate tube, means for heating the substrate tube and means for supporting the substrate tube, characterized in that the device furthermore comprises means for fitting a protective tube round the substrate tube, substantially along the entire length thereof, means for supplying gases to the annular space present between the outer circumference of the hollow substrate tube and the inner circumference of the protective tube, and means for generating a non-isothermal plasma in said annular space,

20. A device according to claim 19, characterized in that the device furthermore comprises means for rotating the protective tube.


resonator for generating plasma
protective tube
substrate tube
deposition of layers
1
2
3
4
5
6
2

FIGURE

INTERNATIONAL SEARCH REPORT

PCT/NL 03/00261

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 C03B37/018

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 C03B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4 746 345 A (PLUIJMS RENE A M ET AL) 24 May 1988 (1988-05-24) cited in the application column 2, line 16 -column 3, line 42; claims; figure 1	1-13,19, 20
Y	US 5 203 691 A (OBRIEN JR WILLIAM D) 20 April 1993 (1993-04-20) cited in the application column 2, line 30 -column 3, line 30	1-13,19, 20
A	US 5 397 372 A (PARTUS FRED P ET AL) 14 March 1995 (1995-03-14) column 6, line 24 - line 59	1-13,19, 20
A	WO 99 35304 A (PLASMA OPTICAL FIBRE BV) 15 July 1999 (1999-07-15) page 1, line 6 - line 31	1-13,19, 20

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 August 2003	04/09/2003

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Reedijk, A

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 007, no. 201 (C-184), 6 September 1983 (1983-09-06) & JP 58 099131 A (NIPPON DENSHIN DENWA KOSHA;OTHERS: 01), 13 June 1983 (1983-06-13) abstract ---	1-13,19, 20
A	US 4 493 721 A (AUWERDA CORNELIS P ET AL) 15 January 1985 (1985-01-15) the whole document -----	1-13,19, 20

INTERNATIONAL SEARCH REPORT

PCT/NL 03/00261

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 15-18
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
see FURTHER INFORMATION sheet PCT/ISA/210

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box I.2

Claims Nos.: 15-18

Present claims 15-18 relate to a product defined by reference to a desirable characteristic or property, namely the refractive index contrast in the case of claims 15 and 16 and the thermal expansion coefficient in the case of claims 17 and 18.

The claims cover all products having this characteristic or property, whereas the application provides support within the meaning of Article 6 PCT and/or disclosure within the meaning of Article 5 PCT for only a very limited number of such products. In the present case, the claims so lack support, and the application so lacks disclosure, that a meaningful search over the whole of the claimed scope is impossible. Independent of the above reasoning, the claims also lack clarity (Article 6 PCT). An attempt is made to define the product by reference to a result to be achieved. Again, this lack of clarity in the present case is such as to render a meaningful search over the whole of the claimed scope impossible. Consequently, the search has been carried out for those parts of the claims which appear to be clear, supported and disclosed, namely those parts relating to the process according to claims 1-14 and to the device according to claims 19 and 20, furthermore the search covered the products that are obtained by carrying out the process as described in claims 1-14.

Furthermore it must be remarked that the use of the parameter concerning the index of refraction contrast in the present context is considered to lead to a lack of clarity within the meaning of Article 6 PCT. It is impossible to compare the parameter the applicant has chosen to employ with what is set out in the prior art.

The applicant's attention is drawn to the fact that claims, or parts of claims, relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure.

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